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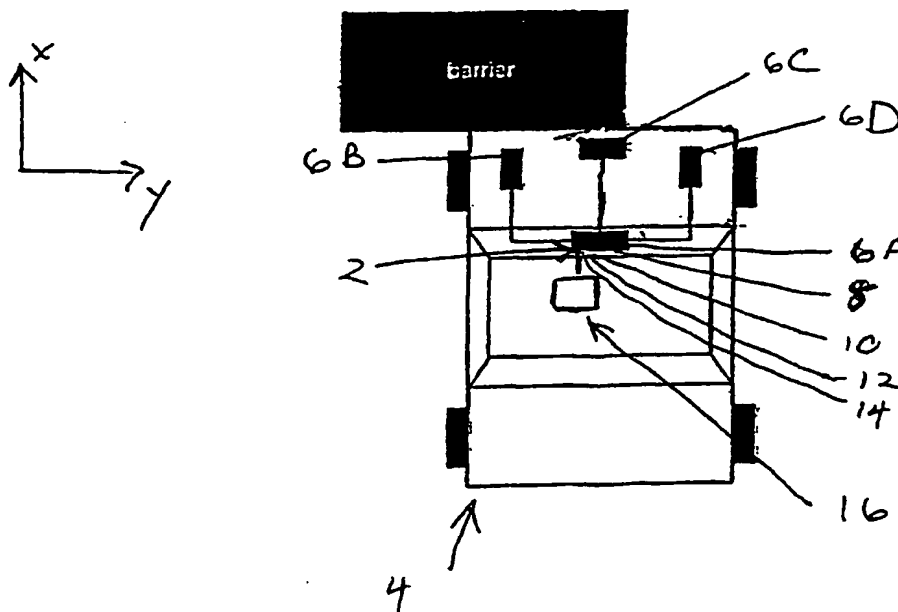
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(54) Title: **DISTRIBUTED ELECTRONIC ACCELERATION SENSING FOR CRASH SEVERITY RECOGNITION**



(57) Abstract: The crash detection system employs a plurality of electronic acceleration sensors distributed at different locations of a vehicle body. The plurality of electronic acceleration sensors measures changes in acceleration of the vehicle body at different locations and therefore the rate of deformation of the vehicle body. The signals from the plurality of electronic acceleration sensors are filtered, amplified, and passed to an evaluation unit, which reads and compares the signals. Based on the rate of deformation of the vehicle body, the evaluation unit then makes a determination of the severity of the vehicle crash and communicates this information to a passenger safety system.

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DISTRIBUTED ELECTRONIC ACCELERATION SENSING FOR CRASH SEVERITY RECOGNITION

BACKGROUND OF THE INVENTION

5 The present invention relates to a system and method for detecting the severity of a crash of a vehicle.

 Vehicles employ passenger safety systems such as air bags and passenger restraints that deploy when a vehicle crash is detected by a crash detection system. Typically, a crash detection system consists of an evaluation unit placed inside the
10 vehicle. The evaluation unit has an electronic acceleration sensor, which detects changes in vehicle velocity from within the unit. The signal from this sensor is filtered and then amplified before processing by a controller. The controller then determines when to activate the vehicle's air bag and passenger restraint systems. When a significant change is detected, the evaluation unit instructs the passenger safety system
15 to deploy.

 Currently, the electronic acceleration sensor is located with the evaluation unit in the console of the vehicle between the driver and passenger. However, this evaluation unit detects changes in the velocity of the vehicle only from a single location of the vehicle body. In a high-speed collision in contrast to a low-speed collision, the
20 vehicle body will deform. Accordingly, the velocity of the vehicle body will vary across the area of the deformation. Current crash detection systems do not detect this difference in velocity and consequently do not measure the rate of vehicle body deformation, which indicates the degree of severity of a vehicle crash.

 Air bag and restraint systems have been developed that deploy to varying
25 degrees to accommodate the varying degrees of intensity of vehicle accidents. For example, air bags that inflate to a higher level in a high-speed collision than in a low-speed collision are known. Passenger restraints may also adjust the level of restraining force based on the accident's intensity. A need therefore exists to determine more precisely the intensity of a vehicle collision.

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SUMMARY OF THE INVENTION

In a disclosed embodiment of this invention, a plurality of electronic acceleration sensors is distributed at different locations of a vehicle body. The plural electronic acceleration sensors measure the change in acceleration of the vehicle body across the area of distribution. Signals from the plurality of electronic acceleration sensors are filtered, amplified, and passed to an evaluation unit, which reads and compares the signals. Based on the rate of deformation of the vehicle body, the evaluation unit then makes a determination of the severity of the vehicle crash and communicates this information to a passenger safety system.

The present invention accordingly measures the severity of a vehicle crash, communicating precise information about the accident to the passenger safety system. Moreover, the use of multiple electronic acceleration sensors creates crash detection system redundancy in event of electronic acceleration sensor failure.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features and advantages of this invention will become apparent to those skilled in the art from the following detailed description of the currently preferred embodiment. The drawings that accompany the detailed description can be briefly described as follows:

Figure 1 shows a crash detection system as known in the prior art consisting of an evaluation unit, including an acceleration sensor, placed at a central location of a vehicle body in collision with a barrier.

Figure 2 shows an embodiment of the present invention, including an evaluation unit and a plurality of acceleration sensors distributed through the vehicle body of

Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In a vehicle collision, a difference in velocity between points of a vehicle body reflects vehicle deformation. Measuring the rate by which the vehicle body deforms provides an indication of the severity of a crash. In a high-speed collision, the rate of deformation is high. In a low-speed collision, the rate is low or zero.

Current crash detection systems do not measure this rate. Figure 1 shows a crash detection system as known in the prior art. The crash detection system includes evaluation unit 2 with an electronic acceleration sensor 6A, which detects the rate of change in velocity of vehicle body 4 at the location of evaluation unit 2. The rate of change is measured along the normal path of vehicle body 4, the x-axis, and may be measured along the y-axis to detect side-impact. Filter 8 and amplifier 10 further processes the signal prior to input into a controller 12, also contained within evaluation unit 2. Controller 12 processes the signal and passes the signal to a communication unit 14, which then transmits the signal to passenger safety system 16 to deploy at a predetermined condition. Passenger safety system 16 is of a known type that is able to provide varying restraining force. The details of system 16 may be as known. The present invention simply provides more accurate feedback of the desired (necessary) restraining force.

The crash detection system as known in the prior art, however, provides limited information about the severity of a collision, apprising passenger safety system 16 only to deploy. The crash detection system does not provide information to passenger safety system 16 as to the level of deployment required to respond more optimally to a crash.

Figure 2 illustrates an embodiment of the present invention. As shown in Figure 2, a plurality of electronic acceleration sensors 6A, 6B, 6C and 6D are distributed at various points of vehicle body 4. In this embodiment, electronic acceleration sensors 6A, 6B, 6C and 6D are distributed at the front of vehicle body 4 as well as centrally. The rate of change is measured along the normal path of vehicle body 4, the x-axis, and may be measured along the y-axis to detect side-impact. Filter 8 and amplifier 10 process the signals from electronic acceleration sensors 6A, 6B, 6C and 6D. Evaluation unit 2 reads and compares the values from electronic acceleration sensors oriented in the same direction, such as 6A and 6C, to measure the deformation rate of vehicle body 4 along an axis, either x-axis, y-axis, or any angle between x-axis and y-axis. Through communication unit 14, evaluation unit 2 communicates with passenger safety system 16. Based upon this measure, evaluation unit 2 processes the signal and communicates precise information about the severity of the vehicle crash to passenger safety system 14.

More specifically, in a front-end collision, electronic acceleration sensor 6A is located in the console between the driver and passenger while electronic acceleration sensor 6C is located toward the front of vehicle body 4. Electronic acceleration sensors 6A and 6C are preferably aligned to make measurements of acceleration along the x-axis to detect a front-end collision. Upon collision, the values from electronic acceleration sensors 6A and 6C are filtered, amplified and passed to evaluation unit 2.

After converting the acceleration values to velocity, evaluation unit 2 examines the difference in the velocities as measured by electronic acceleration sensors 6A and 6C to arrive at a velocity of the passenger cab relative to the front of the vehicle.

$$V_{\text{passenger cab}} = V_{6A} - V_{6C}$$

The velocity of the passenger cab is then multiplied by a force constant to arrive at an estimate of the restraining force needed by the passenger in the collision.

$$\text{Restraining Force} = f(V_{\text{passenger cab}})$$

The greater the difference between velocities measured by electronic acceleration sensors 6A and 6C the greater restraining force is required. Evaluation unit 2 then transmits this information via communication unit 14 to passenger safety system 16. In this manner, evaluation unit 2 provides information to passenger safety system 16 about the degree of intensity of the collision. A side-impact collision is detected in the same manner with electronic acceleration sensors 6B and 6D oriented relative to vehicle body 4 to take measurements of acceleration preferably along the y-axis. Other forms of the present invention can make detections of vehicle deformation and therefore crash severity in any direction by placing electronic acceleration sensors 6 at different locations of vehicle body 4 and aligning any two sensors 6 in any desired direction.

The aforementioned description is exemplary rather than limiting. Many modifications and variations of the present invention are possible in light of the above teachings. The preferred embodiments of this invention have been disclosed. However, one of ordinary skill in the art would recognize that certain modifications would come within the scope of this invention. Hence, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described. For this reason the following claims should be studied to determine the true scope and content of this invention.

CLAIMS

1. A crash detection system comprising:
a plurality of sensors located at different points of a vehicle, at least two
5 of said plurality of sensors making measurements in the same direction; and
an evaluation unit for reading and comparing the signals of said
plurality of sensors to determine the severity of a vehicle crash by examining the
difference in values from said plurality of sensors.
- 10 2. A crash detection system of claim 1, including a communication unit for
transmitting the signal generated by said evaluation unit to a passenger safety system.
3. A crash detection system of claim 2, wherein said passenger safety
system is operable to provide varying levels of restraining force in response to varying
15 degrees of crash severity.
4. A crash detection system of claim 1, wherein at least two of said
plurality of sensors take measurements along a direction of forward travel.
- 20 5. A crash detection system of claim 1, wherein at least two of said
plurality of sensors take measurements along a direction of travel transverse to forward
travel.
- 25 6. A crash detection system of claim 4, wherein at least two of said
plurality of acceleration sensors make measurements along a direction of travel
transverse to forward travel.
7. A crash detection system of claim 1, wherein said evaluation unit
determines the difference of signals to determine the severity of a crash;
- 30

8. A crash detection system of claim 1, wherein said sensors are acceleration sensors.

5 9. A method for detecting the severity of a vehicle crash comprising:
providing a network of acceleration sensors at different points of a vehicle;

reading the values generated by the acceleration sensors;
comparing the values generated by the acceleration sensors; and
determining the severity of a vehicle crash based on the difference in
10 values generated by the acceleration sensors.

10. The method of claim 9, including the step of signaling a passenger safety system to deploy to a degree based on the difference in values generated by the acceleration sensors.

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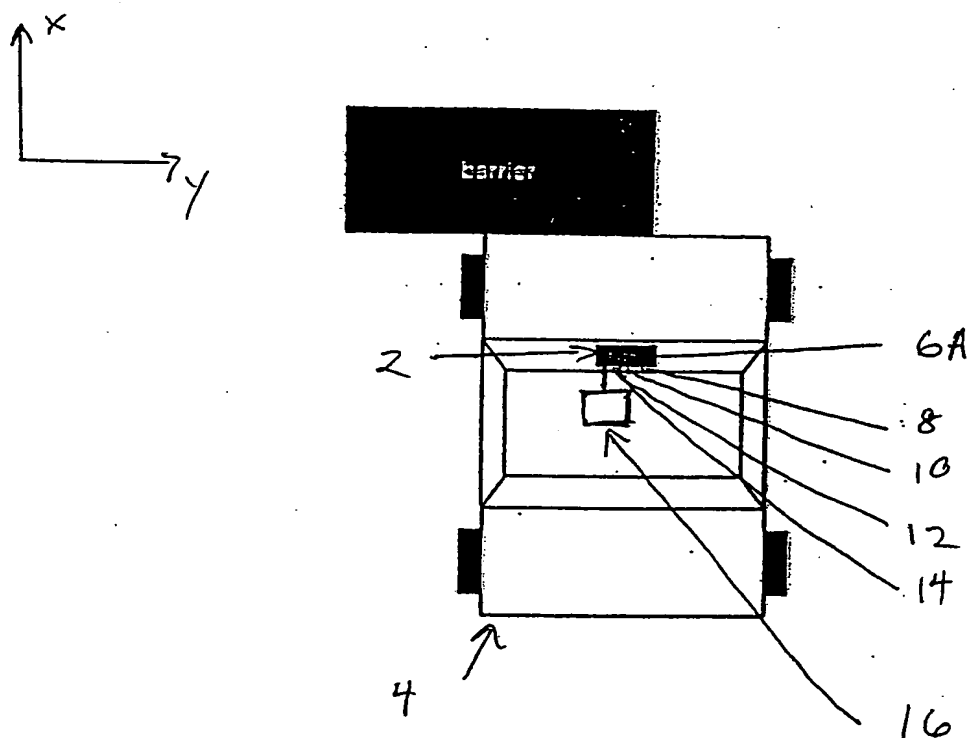
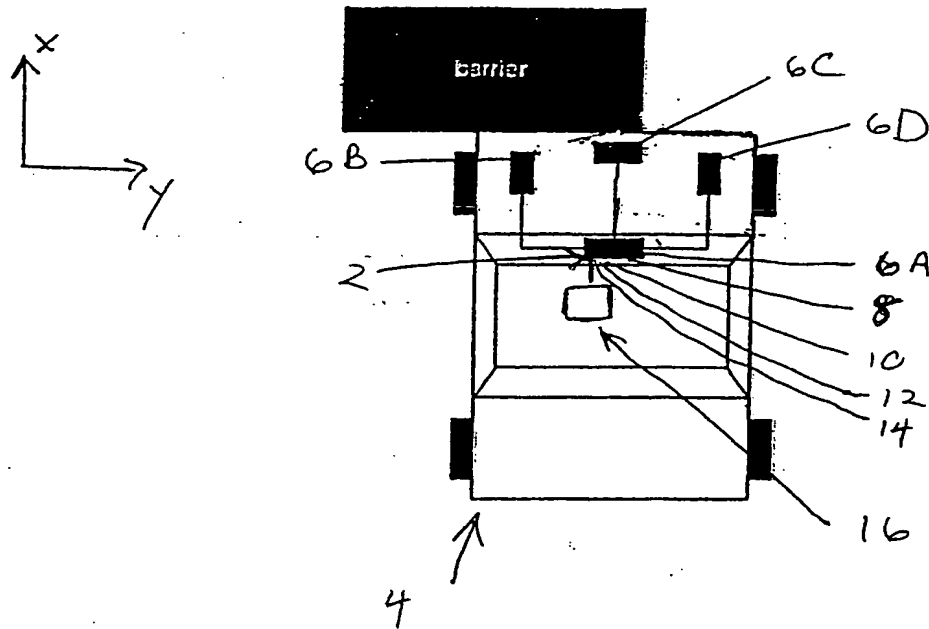
Figure 1Prior
Art

Figure 2

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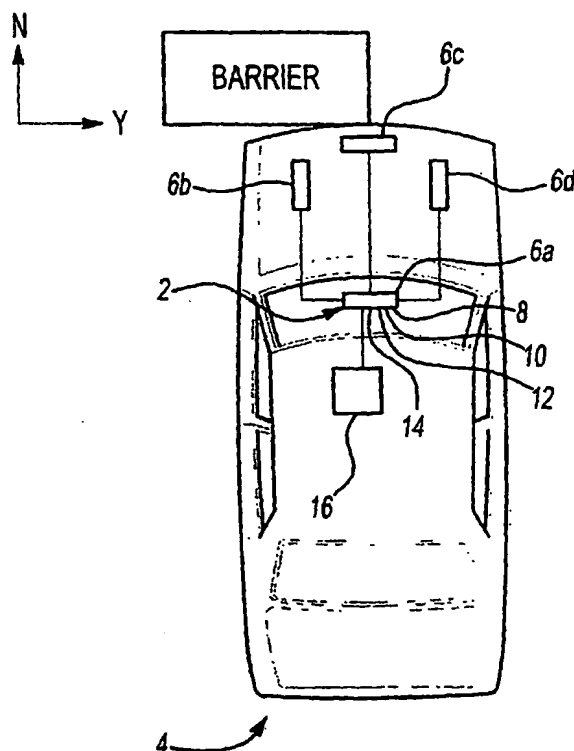
(71) Applicant: **SIEMENS AUTOMOTIVE CORPORATION** [US/US]; 2400 Executive Hills Boulevard, Auburn Hills, MI 48326-2980 (US).

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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60R21/01

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 967 548 A (KOZYREFF MICHEL) 19 October 1999 (1999-10-19)	1-4, 7-10
Y	column 2, line 65 -column 4, line 40 column 4, line 64 -column 5, line 9 figures 1, 2	5, 6
X	WO 98 51544 A (ONO MITSURU ; SADA HIROYUKI (JP); AUTOLIVE JAPAN LTD (JP); MORIYAMA) 19 November 1998 (1998-11-19)	1-4, 7-10
Y	& EP 0 982 199 A (AUTOLIVE JAPAN LTD) 1 March 2000 (2000-03-01) column 6, line 41 -column 7, line 6 column 7, line 36 -column 9, line 5 column 9, line 51 -column 10, line 19 figure 1	5, 6
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☒ Further documents are listed in the continuation of box C.

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& document member of the same patent family

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	DE 197 40 019 A (SIEMENS AG) 25 March 1999 (1999-03-25) column 3, line 24 -column 4, line 5 column 4, line 40 - line 53 column 5, line 39 -column 6, line 21 figures 1,4,5 -----	1,9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

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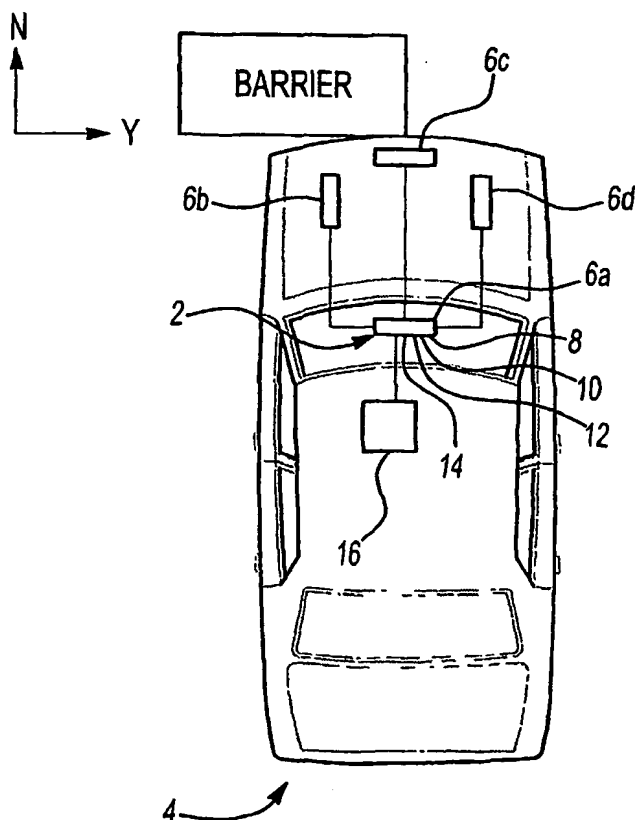
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[Continued on next page]

(54) Title: DISTRIBUTED ELECTRONIC ACCELERATION SENSING FOR CRASH SEVERITY RECOGNITION



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15 to deploy.

 Currently, the electronic acceleration sensor is located with the evaluation unit in the console of the vehicle between the driver and passenger. However, this evaluation unit detects changes in the velocity of the vehicle only from a single location of the vehicle body. In a high-speed collision in contrast to a low-speed collision, the
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30

SUMMARY OF THE INVENTION

In a disclosed embodiment of this invention, a plurality of electronic acceleration sensors is distributed at different locations of a vehicle body. The plural electronic acceleration sensors measure the change in acceleration of the vehicle body across the area of distribution. Signals from the plurality of electronic acceleration sensors are filtered, amplified, and passed to an evaluation unit, which reads and compares the signals. Based on the rate of deformation of the vehicle body, the evaluation unit then makes a determination of the severity of the vehicle crash and communicates this information to a passenger safety system.

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Figure 2 shows an embodiment of the present invention, including an evaluation unit and a plurality of acceleration sensors distributed through the vehicle body of

Figure 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In a vehicle collision, a difference in velocity between points of a vehicle body reflects vehicle deformation. Measuring the rate by which the vehicle body deforms provides an indication of the severity of a crash. In a high-speed collision, the rate of deformation is high. In a low-speed collision, the rate is low or zero.

Current crash detection systems do not measure this rate. Figure 1 shows a crash detection system as known in the prior art. The crash detection system includes evaluation unit 2 with an electronic acceleration sensor 6A, which detects the rate of change in velocity of vehicle body 4 at the location of evaluation unit 2. The rate of change is measured along the normal path of vehicle body 4, the x-axis, and may be measured along the y-axis to detect side-impact. Filter 8 and amplifier 10 further processes the signal prior to input into a controller 12, also contained within evaluation unit 2. Controller 12 processes the signal and passes the signal to a communication unit 14, which then transmits the signal to passenger safety system 16 to deploy at a predetermined condition. Passenger safety system 16 is of a known type that is able to provide varying restraining force. The details of system 16 may be as known. The present invention simply provides more accurate feedback of the desired (necessary) restraining force.

The crash detection system as known in the prior art, however, provides limited information about the severity of a collision, apprising passenger safety system 16 only to deploy. The crash detection system does not provide information to passenger safety system 16 as to the level of deployment required to respond more optimally to a crash.

Figure 2 illustrates an embodiment of the present invention. As shown in Figure 2, a plurality of electronic acceleration sensors 6A, 6B, 6C and 6D are distributed at various points of vehicle body 4. In this embodiment, electronic acceleration sensors 6A, 6B, 6C and 6D are distributed at the front of vehicle body 4 as well as centrally. The rate of change is measured along the normal path of vehicle body 4, the x-axis, and may be measured along the y-axis to detect side-impact. Filter 8 and amplifier 10 process the signals from electronic acceleration sensors 6A, 6B, 6C and 6D. Evaluation unit 2 reads and compares the values from electronic acceleration sensors oriented in the same direction, such as 6A and 6C, to measure the deformation rate of vehicle body 4 along an axis, either x-axis, y-axis, or any angle between x-axis and y-axis. Through communication unit 14, evaluation unit 2 communicates with passenger safety system 16. Based upon this measure, evaluation unit 2 processes the signal and communicates precise information about the severity of the vehicle crash to passenger safety system 14.

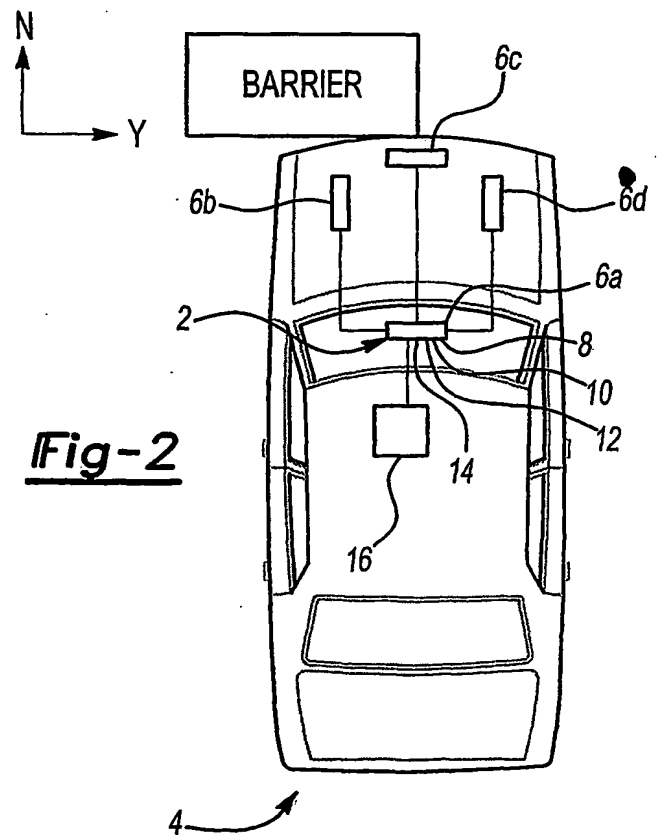
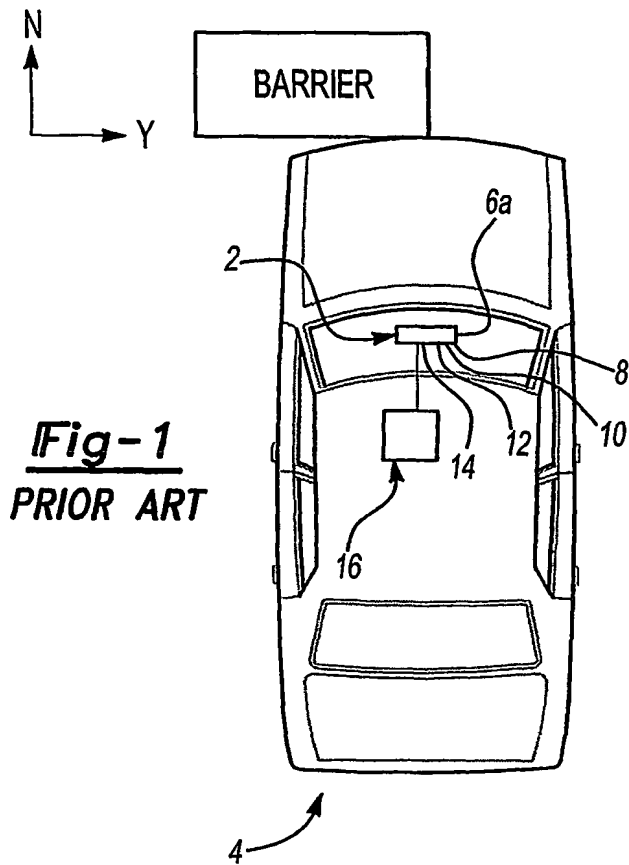
8. A crash detection system of claim 1, wherein said sensors are acceleration sensors.

5 9. A method for detecting the severity of a vehicle crash comprising:
providing a network of acceleration sensors at different points of a
vehicle;
reading the values generated by the acceleration sensors;
comparing the values generated by the acceleration sensors; and
determining the severity of a vehicle crash based on the difference in
10 values generated by the acceleration sensors.

10. The method of claim 9, including the step of signaling a passenger
safety system to deploy to a degree based on the difference in values generated by the
acceleration sensors.

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1/1



SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

Int'l Application No

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A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B60R21/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

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Y	column 2, line 65 -column 4, line 40 column 4, line 64 -column 5, line 9 figures 1,2	5,6
X	WO 98 51544 A (ONO MITSURU ;SADA HIROYUKI (JP); AUTOLIVE JAPAN LTD (JP); MORIYAMA) 19 November 1998 (1998-11-19)	1-4,7-10
Y	& EP 0 982 199 A (AUTOLIVE JAPAN LTD) 1 March 2000 (2000-03-01) column 6, line 41 -column 7, line 6 column 7, line 36 -column 9, line 5 column 9, line 51 -column 10, line 19 figure 1	5,6
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INTERNATIONAL SEARCH REPORT

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